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**National Highway
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DYNAMIC SCIENCE, INC.
In-Depth Accident Investigation

Case Number DSI-96-AB-003

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

DYNAMIC SCIENCE, INC.
AIRBAG FIRE INVESTIGATION
CASE NUMBER: DSI-96-AB-003

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Airbag Fire Investigation

Contractor: Dynamic Science, Inc.
Contract Number: DTNH22-94-D-27058
Case Number: Case DSI-95-AB-03

D. Davis

Case Selection: As the result of an alleged interior electrical wiring fire, the driver's side airbag in a 1994 Dodge pick up truck self deployed. During this deployment the airbag inflator separated from the steering wheel and was projected through the rear wall of the truck cab.

Pre-Event: This event occurred on private property in a rural area of [REDACTED] on Monday, [REDACTED] 1996 at approximately 1300 hours. The weather was clear, there was a light wind of approximately 16 to 24 km/h (10 to 15 MPH) from an unknown direction and the temperature was 2° C (35° F). The ground was ice and snow covered.

The case vehicle was a 1994 Dodge Ram 1500 pick up truck, VIN 1B7HC16Y9RSxxxxxx. The vehicle was equipped with a 5.2 L V8 engine, automatic transmission and an HDPE gasoline tank located forward of the rear axle, centered and near the cab. The fuel filler cap was located on the left side plane of the cargo box, forward of the rear axle. The vehicle's wheels appeared to be chromed steel, there were after-market aluminum running boards and the cargo box was covered by a fiberglass cap.

The left and right front seats were adjustable bucket seats with folding back rests. The center seat was a fixed, non-adjustable bucket seat with a folding back rest. All three seats were covered with a nylon-like fabric. The left front seat appears to have been adjusted to the rear most seat track position. The vehicle was also equipped with a tilt steering wheel which appears to have been adjusted downward 2 positions from center.

The owner stated the vehicle was purchased used from the local Ford dealer in [REDACTED] 1995. At the time of purchase the vehicle's cruise control was inoperable. In [REDACTED] or [REDACTED] 1995, the owner took the vehicle to the local Dodge dealer to have the cruise control repaired. It was determined that the cruise control on/off switch, located on the turn signal lever, was faulty. The owner had a new switch installed by the Dodge dealer, and according to the owner "...the cruise control worked just fine from that time on."

The owner said the vehicle was in good condition, routinely maintained and never abused or involved in an accident. The vehicle's mileage, at the time of the fire, was approximately 53,100 km (33,000 mi) according to the

owner. When asked specific questions regarding possible flammable fluid leaks and/or faulty wiring, the owner replied that he had never smelled “raw gasoline” fumes, hot wiring or hot rubber odors prior to this incident. He also stated he had never observed oil or gas “pooling” in areas where he routinely parked the vehicle. The owner also stated that he had never had a problem with the truck being hard to start, running “roughly” or unusually high gasoline consumption.

The owner did not recall ever having hit, or run over, any object that could have damaged the vehicle’s gas tank or gas lines. He also stated that he did not have any flammable fluids stored in the vehicle, other than the gasoline tank.

The owner of the case vehicle, a 54 year old male, was visiting at a relative’s home which is accessed from a public highway by a narrow, dirt farm lane approximately 402 m (1,320 ft) in length. Approximately half way between the home and the highway, the dirt lane crosses a small creek on a wooden bridge.

After completing the visit, the owner reports that he had driven down the lane approximately 201 m (660 ft) when he “...smelled something hot, like rubber burning.” Upon crossing the bridge he allegedly stopped, turned off the engine and got out of the truck. The owner stated there was no smoke or fire in the truck cab at this time.

Event:

Upon opening the hood, the owner observed flames around the right back side of the engine and “...coming up the sides.” The owner stated that he picked up several hands full of snow and threw them on the engine in an effort to extinguish the flames. The snow being insufficient, the owner retrieved a bucket from the cargo box of the truck. The owner stated, “I went down to the creek three times, filled the bucket with water and returned to the truck where I threw the water on the fire.” According to the owner, he closed the hood each time before going to the creek. Upon returning to the truck during the third trip to the creek, the owner said “I couldn’t get the hood open because it had melted closed.”

At this point, with the engine compartment fully involved, the owner opened the left door and began to remove personal items from the truck cab. He said as he was leaning across the left front seat, he observed that fire and smoke were coming into the cab from under the passenger’s side instrument panel (most likely through the fire wall openings for the heater/air conditioner). After having removed a few items, the owner states “...I had to get out of the truck because the smoke got too bad.”

Being unable to enter the truck, the owner started walking back to his relative’s house to call the fire department. As he left the truck he apparently did not close the left door which allowed the fire to be drawn strongly to the left side of the cab. After crossing the bridge, the owner

heard an explosion he could describe only as "...being louder than a shotgun." At the time he attributed the explosion to the gas tank, but now believes it was the airbag self deploying. This explosion appears to have been some 15 to 20 minutes after he first "smelled something hot."

Post-Event:

Upon arriving at the relative's home, the owner called the fire department. The emergency dispatcher advised him the fire had already been reported and that a fire truck was en route (the fire department reports the initial call came from a neighbor at 1319 hours).

The owner immediately returned to his truck, bringing with him a video camera. He stated the truck was still burning, but had been totally destroyed. As he started to video tape the truck, the fire department arrived. The owner states the fire department used "foam" to extinguish the remaining flames, and to ensure the truck would not re-ignite.

**Vehicle
Inspection:**

Dynamic Science's on-site vehicle inspection was conducted 30 days post-event, and within 3 days of notification. (Note: All of the following temperature estimates are for zinc chromate primer as listed in the U.S. Coast Guard's *Melting Temperatures and Temperature Indicators of Common Elements* found in DOT/U.S. Coast Guard Federal Regulation 33, Parts 1-199.)

Exterior:

Left Side - The left front fender was burned to metal and was rusting (primer completely burned, temperature above 371° C (700° F). The deflated left front tire had areas of charring from direct flame contact and the chrome plated wheel was discolored by heat (Photo 2). The left front door and cargo box exterior surface showed heat damage, but the primer was gray-white in color indicating a temperature < 232° C (450° F). The black, vinyl-like left side molding was in place, showed no evidence of fire damage, but was soot covered. The gas filler door was open and charred black (Photos 2 and 5). The non-metal gas filler cap could not be located - it appears to have melted, but no residue could be found. The left aluminum running board sustained no fire damage, but several attachment screws were missing and assumed to have been destroyed by heat (Photos 2 and 5). The left door glazing appears to have melted down the exterior of the door - no left side glass residue was found inside the truck (Photos 2 and 5). The left "A" pillar was burned to the metal indicating a temperature greater than 371° C (700° F) (Photos 1 and 2). The deflated left rear tire was charred and the chrome plated wheel was discolored by heat (Photos 2 and 5). There was no apparent heat deformation of the left side plane metal. Black areas on the left side appeared to be charred paint (Photos 5 and 7).

Cargo Box - Residue from the burned fiberglass cap covered the bed of the cargo box (Photos 9, 54 and 55). The right side interior wall sustained heat damage, but the gray-white primer remained indicating a temperature in the area of $<232^{\circ}\text{C}$ (450°F) (Photos 5 and 7). The left side and front walls sustained fire damage and were rusting indicating a temperature $>371^{\circ}\text{C}$ (700°F) in these areas (Photos 6 and 8).

The left front cargo box wall had a round, conical deformation caused by the impact of the airbag inflator. The rearward deformation was approximately 14.5 cm (5.7 in) in depth, and approximately 8.5 cm (3.3 in) in diameter. This deformation was located 21.5 cm (8.5 in) below the top edge of the cargo box, and 32.5 cm (12.8 in) right of the left front door latch pillar (Photos 3, 4 and 6). Directly above the area of maximum deformation, the top edge of the cargo box was deformed rearward approximately 4.5 cm (1.8 in) (Photos 3 and 4). The truck's rear window glazing melted and fell inward into the interior of the cab.

Right Side - The right front fender, door, "A" pillar and forward quarter of the cargo box evidenced fire damaged primer that indicates temperatures ranged from $>232^{\circ}\text{C}$ (450°F) to $>371^{\circ}\text{C}$ (700°F) (Photos 8 and 11). The right rear tire, and chrome wheel, were soot covered, but showed no charring or discoloration. The right rear tire was not deflated (Photo 11). The black, vinyl-like right side molding was completely destroyed and no residue could be found (Photos 8 and 11). The rear portion of the aluminum running board was melted, and deformed, by apparent direct flame contact (Photos 8 and 11). The glazing in the right door melted and fell into the interior of the cab. The right front tire was deflated and charred. The chrome plated wheel was discolored by heat (Photo 11).

Cab Top - The entire top of the cab was devoid of primer and was rusting. In addition, the top was depressed on the center left side as a result of heat induced temper loss (Fire Department temperature estimate $>483^{\circ}\text{C}$ (900°F)) (Photos 2 and 11).

Front - The grille, right and left headlights, and all right and left light components were completely destroyed by direct fire contact. The left front bumper support was heat deformed and the bumper was lowered approximately 5 to 8 cm (2 to 3 in) as a result. The chrome plated bumper was discolored and the black, vinyl-like bumper insert strip was completely destroyed by direct fire contact (Photos 1 and 2). This bumper support deformation, and the lowering of the bumper, may have been the result of earlier investigations (Photo 51). The entire windshield melted and fell inward into the interior of the cab (Photos 1 and 2).

Engine Compartment - The engine coolant radiator and the air conditioning coils were completely melted by direct fire contact (Photos 1 and 2). In addition, the upper and lower radiator supports were deformed by fire and heat. All engine compartment hoses and wiring were destroyed by direct

fire contact. The alloy and composition engine components, especially at the right rear of the engine, were melted or deformed by fire contact. The firewall appears to have been deformed on the right side by a loss of temper (hood could not be opened for photo).

The hood of the vehicle was rusting from loss of primer, and there was a loss-of-temper depression near the rear edge on the right side (Photos 2 and 4).

Interior - The vehicle interior was completely gutted with all fabric, vinyl and plastic trim being completely burned to unidentifiable residue left on the floor of the vehicle. The interior burn patterns were relatively uniform with the right side and entire instrument panel sustaining the severest damage (Photos 21 and 22). In these areas, the temperatures are estimated to have been well above 371° C (700° F) with metal deformation and the melting of attachment screws on the left instrument panel and steering column. The back wall of the cab, and the left front seat sustained estimated temperatures ranging from 232° C (450° F) to >371° C (700° F) (Photos 14-20). The interior trim panel of the left front door was completely burned, but the metal door surface retained the gray/white primer indicating the door was subject to temperatures estimated to have been <232° C (450° F). The condition of this door indicates that it was, in fact, open during the course of this fire (Photos 19 and 20).

As the metal screws attaching the instrument panel to the left side of the truck cab melted, the instrument panel dropped carrying the steering wheel/steering column with it. It also appears that at some point, the steering column separated from its instrument panel attachment device (Photos 25, 57 and 58).

Due to prior vehicle inspections, the wiring found during Dynamic Science's inspection could not be attributed to any specific component or wiring harness. However, the wiring that was found in the truck cab had sustained varying degrees of damage that ranged from relatively pliable to brittle with some beading.

The left rear wall of the truck cab contained an 8.5 cm (3.3) diameter hole. This hole was located, on center, 32.5 cm (12.8 in) right of the left door latch pillar, 35.6 cm (14 in) above the rear floor and 36.8 cm (14.5 in) below the lower edge of the rear window. This hole, made by the airbag inflator, completely pierced the rear wall and was in direct line with the cargo box deformation (Photos 13-20).

**Exemplar
Vehicle:**

Interior measurements were made in an undamaged 1994 Dodge Ram 1500 pick up truck. The exemplar vehicle did not have a tilt steering wheel or bucket seats, but was identical in all other respects to the case vehicle.

Measurements: The back floor is 12 cm (4.7 in) higher than the front floor. The transition is back of the forward seat anchor.

Firewall to backwall of the cab	=	167.6 cm (66.0 in)
Firewall to steering wheel hub (center)	=	78.0 cm (30.7 in)
Steering wheel hub (center) to seat back rest (seat adjusted to rearmost track position)	=	61.6 cm (24.3 in)
Top of head rest from rear floor	=	90.0 cm (35.4 in)
Top of seat from rear floor	=	74.0 cm (29.1 in)
Front floor to steering wheel hub (center)	=	72.0 cm (28.3 in)
Front floor to steering column (at firewall)	=	30.6 cm (12.0 in)
Front floor to top of seat cushion	=	42.0 cm (16.5 in)
Left sill to steering wheel hub (center)	=	35.0 cm (13.8 in)
Approximate steering column angle	=	30°

Considerations: Origin of Fire -

1. The owner stated in his interview that he had not noticed any unusual "electrical odors" prior to this incident, nor had he had any electrical problems with his truck. According to him the vehicle ran good and all of the electrical components were operable.
2. The owner stated he had not smelled the odor of gasoline, nor noticed the pooling of gas or oil where he normally parked is truck.
3. At the time of the event, the driver stated he had smelled "rubber burning". He said the smell was not that of hot or burning electrical wires.
4. The driver did not indicate the presence of smoke or fire in the cab of the truck as he brought it to a stop.
5. When first observed, the fire was at the right rear area of the engine compartment and "...coming up around the sides of the engine."
6. The fuel pump for the case vehicle is located inside the fuel tank, attached to the center of the top side of the tank. The vehicle's gas line exits the right side of the fuel tank, runs under the right side of

the truck and enters the right rear corner of the engine compartment.

7. The heaviest fire damage appears to have been in the engine compartment, right interior and the entire instrument panel.

Based on the above, and the burn pattern, front to rear and right to left, it would appear that the left side instrument panel wiring or steering column wiring were not the cause of this fire.

The more probable cause of this fire would be a flammable liquid ignited by ignition system components located in the engine compartment. The probability of this cause is based on the location of flames when the fire was first observed, the extensive engine compartment damage and the interior fire first being observed under the right and center instrument panel at, or near, the firewall.

Airbag Deployment

1. Prior to the airbag deploying, the majority of the fire was located on the right, and right center front areas of the truck cab.
2. The owner was leaning inside the vehicle retrieving personal items and he did not indicate the presence of "excessive" heat. He was forced out of the vehicle by the smoke.
3. It was several minutes after being "forced" out of the truck by the thick smoke that the driver heard the explosion that he attributed to the airbag deploying.
4. From *Surface Vehicle Information Report*, SAE J2074 issued 6/18/93, page 5, 7.2: "Vehicle Fires - If there is a fire in an airbag-equipped vehicle, the airbags are designed to self-deploy if their internal temperature reaches approximately 149° C (300° F).

Based upon interior vehicle temperature estimates, fire location, the open left front door and the above, it appears possible that the airbag began to deploy as designed.

Airbag Inflator

1. The diffuser and combustion chamber were found between the back wall of the truck cab and the front wall of the cargo box. Remnants of the final filter were attached to the diffuser (Photos 44, 45, 49 and 50).
2. The top of the diffuser was convex from internal pressure (Photos 44-46).

3. The diffuser does not appear to have sustained any damage, or deformity, from cab wall or cargo box contact.
4. Steering column angle was approximately 30° and the steering wheel was tilted downward approximately 2 positions.
5. Based on the relatively flat trajectory of the diffuser, it appears the steering wheel/steering column had dropped downward approximately 25 cm (10 in) at the time the airbag began to inflate (Photo 20).
6. The steering column/steering wheel were found lying on the left front floor after the fire was extinguished. Found immediately rearward of the steering wheel/steering wheel hub, just forward of the left front seat, were the inflator's chamber cover, deformed initiator retainer, slag filter, airbag attachment ring and module attachment device (Photos 62 and 63).
7. The steering wheel's airbag module attachment point was deformed (Photos 26-31).
8. It appears that the diffuser and combustion chamber were forcibly separated from the chamber cover (Photos 34-37 and 47-50).

The cause(s) of these various component separations could not be determined, nor could the sequence of separations be identified.

List of Abbreviations

FT	Feet
IN	Inches
AME	After Market Equipment
AIS	Abbreviated Injury Scale
CCW	Counterclockwise
CDC	Collision Deformation Classification
C/F	Center Front
CG	Center of Gravity
CM	Centimeter
C/R	Center Rear
CW	Clockwise
E, EB	East, Eastbound
FRP	Final Rest Position
KG	Kilogram
KM/H	Kilometers per Hour
L/F	Left Front
L/R	Left Rear
M	Meter
N, NB	North, Northbound
NE	Northeast
NW	Northwest
OEM	Original Equipment Manufacturer
PDOF	Principal Direction of Force
POI	Point of Impact
R	Radius of Curvature
R/F	Right front
RL	Reference Line
RP	Reference Point
R/R	Right rear
S, SB	South, Southbound
SE	Southeast
SW	Southwest
V1	Vehicle 1
W, WB	West, Westbound

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Case No. DSI-96-AB-003

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AB03-020









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AB03-030



AB03-031



AB03-032



AB03-033



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AB03-035



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AB03-037



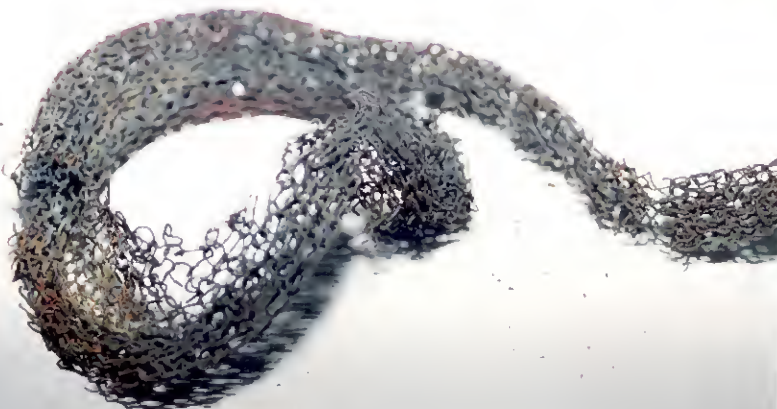
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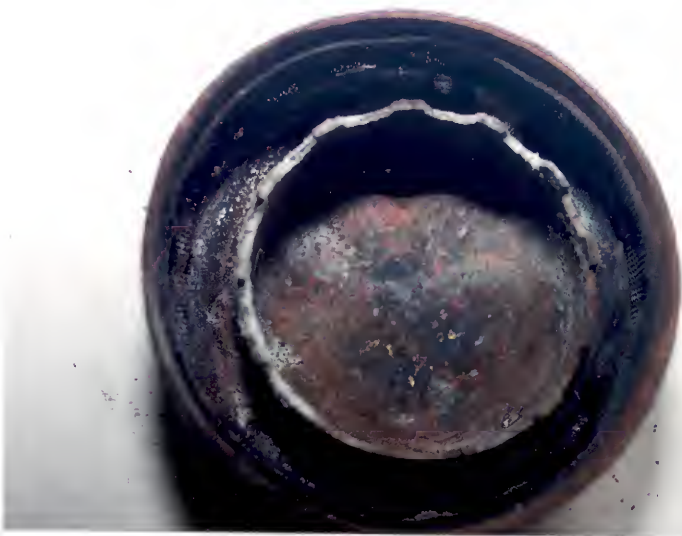
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AB03-049



AB03-050







AB03-053



AB03-054









AB03-061



AB03-062

